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(54) **ELECTRONICS RACK WITH SELECTIVE ENGAGEMENT OF HEAT SINK**

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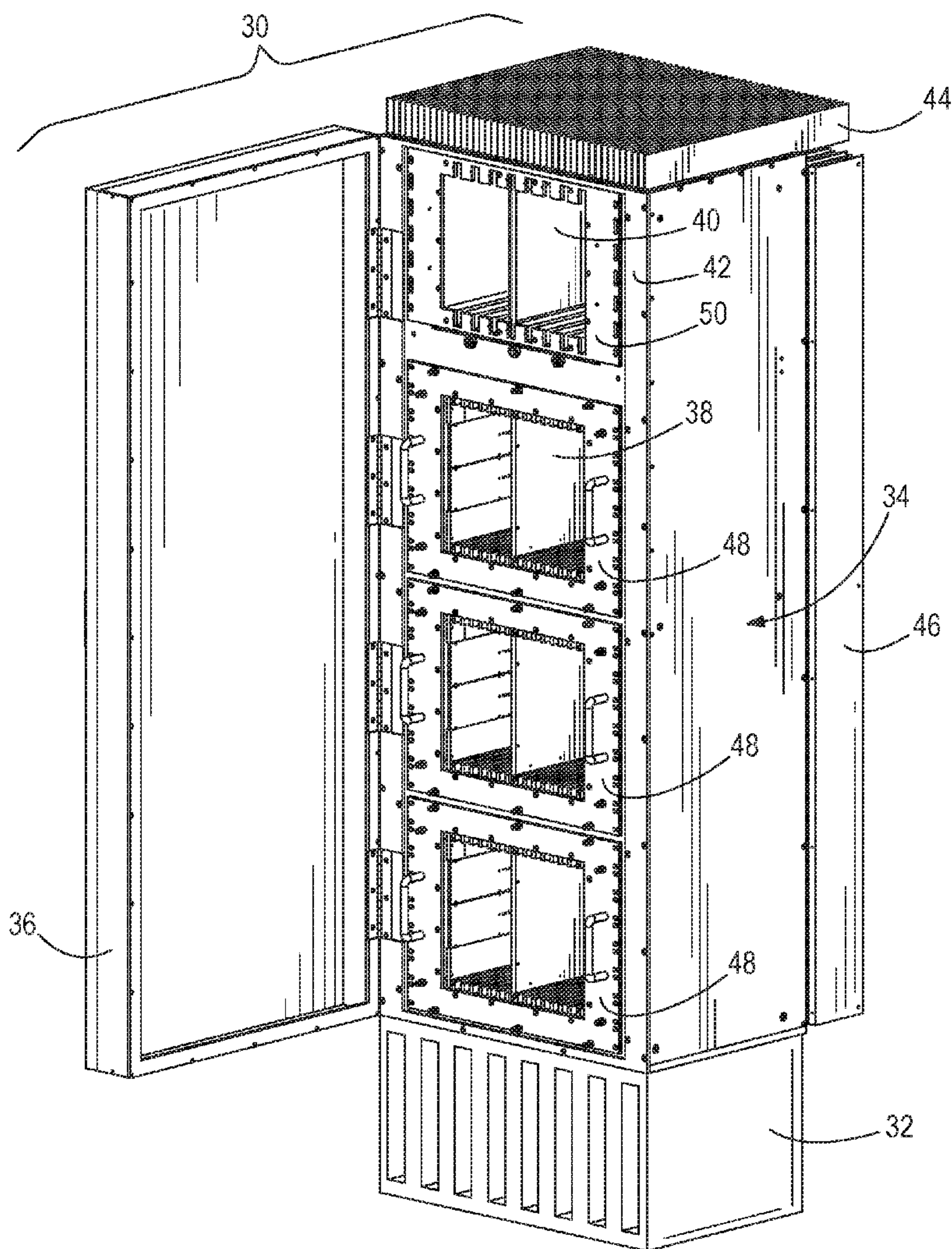
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(57) **ABSTRACT**

An electronics rack comprising a frame, a heat sink coupled to the frame, and a cage adapted to support an electronic component. The cage is movable between first and second positions toward and away from the heat sink. The rack further includes an eccentric cam operatively positioned between the frame and the cage and being rotatable to move the cage between the first and second positions. In one embodiment, the cage comprises a cooling brick movable toward and away from the heat sink when the cage moves between the first and second positions. The cooling brick can include a first heat pipe extending generally in a first direction and a second heat pipe extending generally in a second direction transverse to the first direction. For example, the first heat pipe can be embedded in a top plate and the second heat pipe can be embedded in a top cold rail.



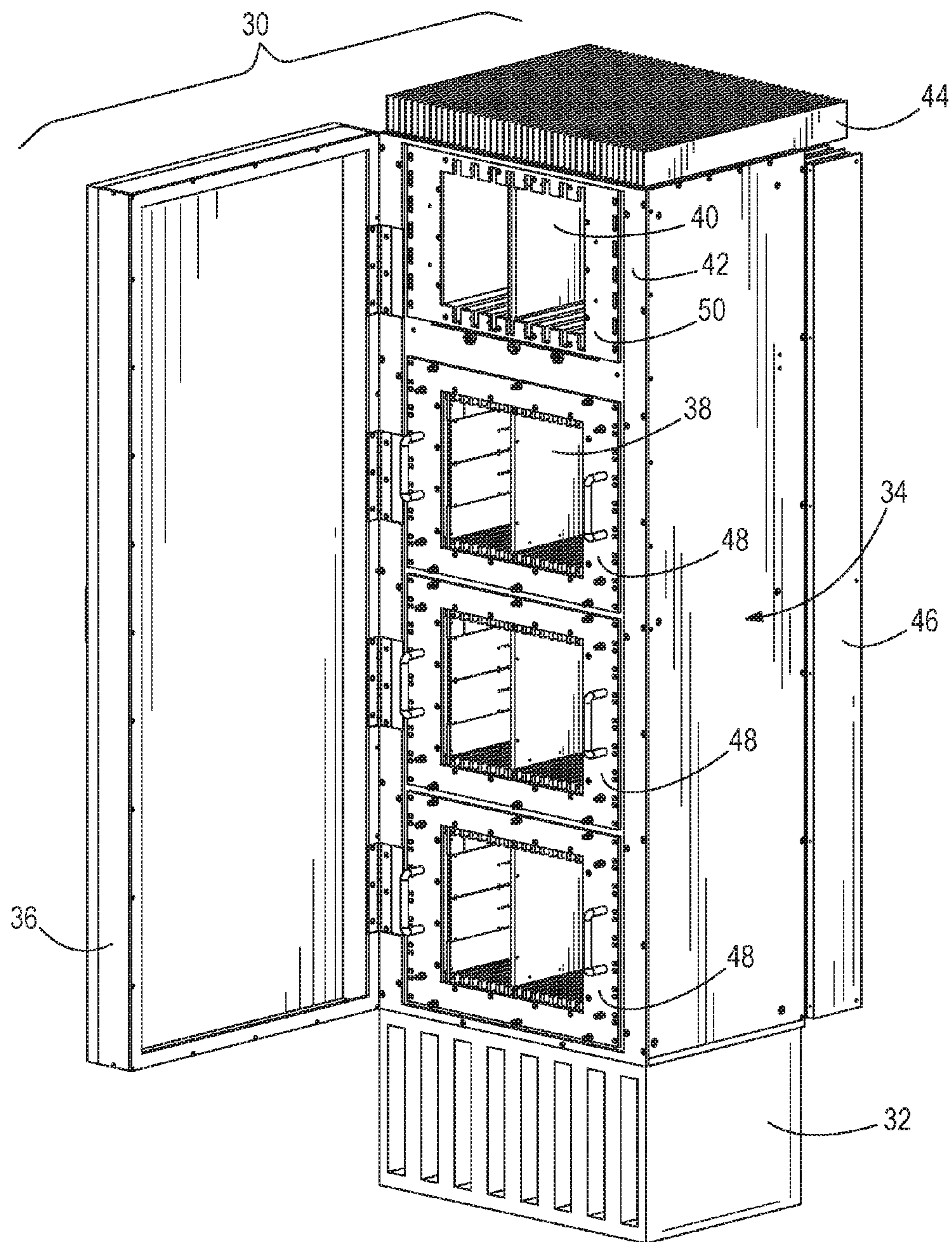


FIG. 1

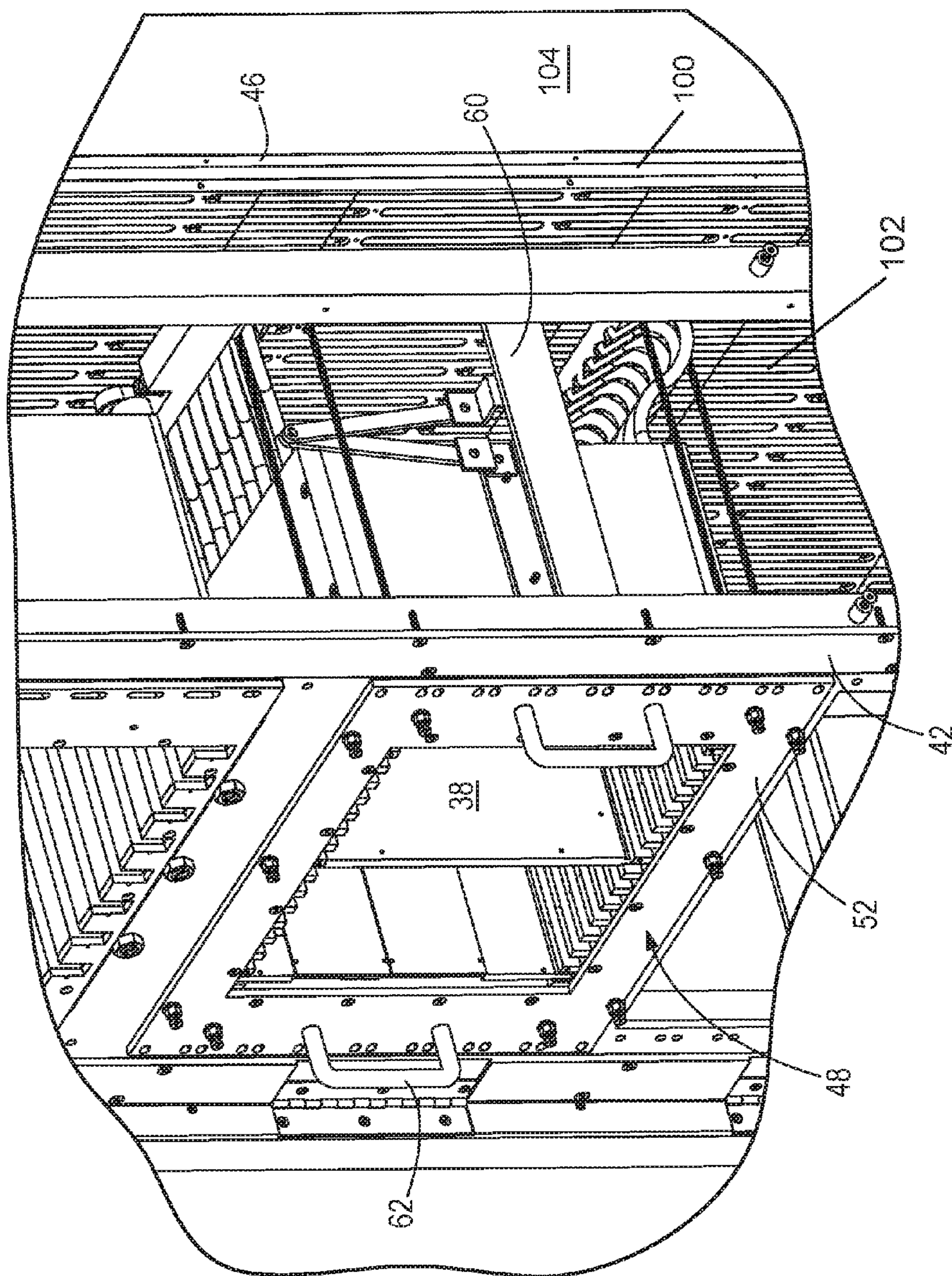


FIG. 2

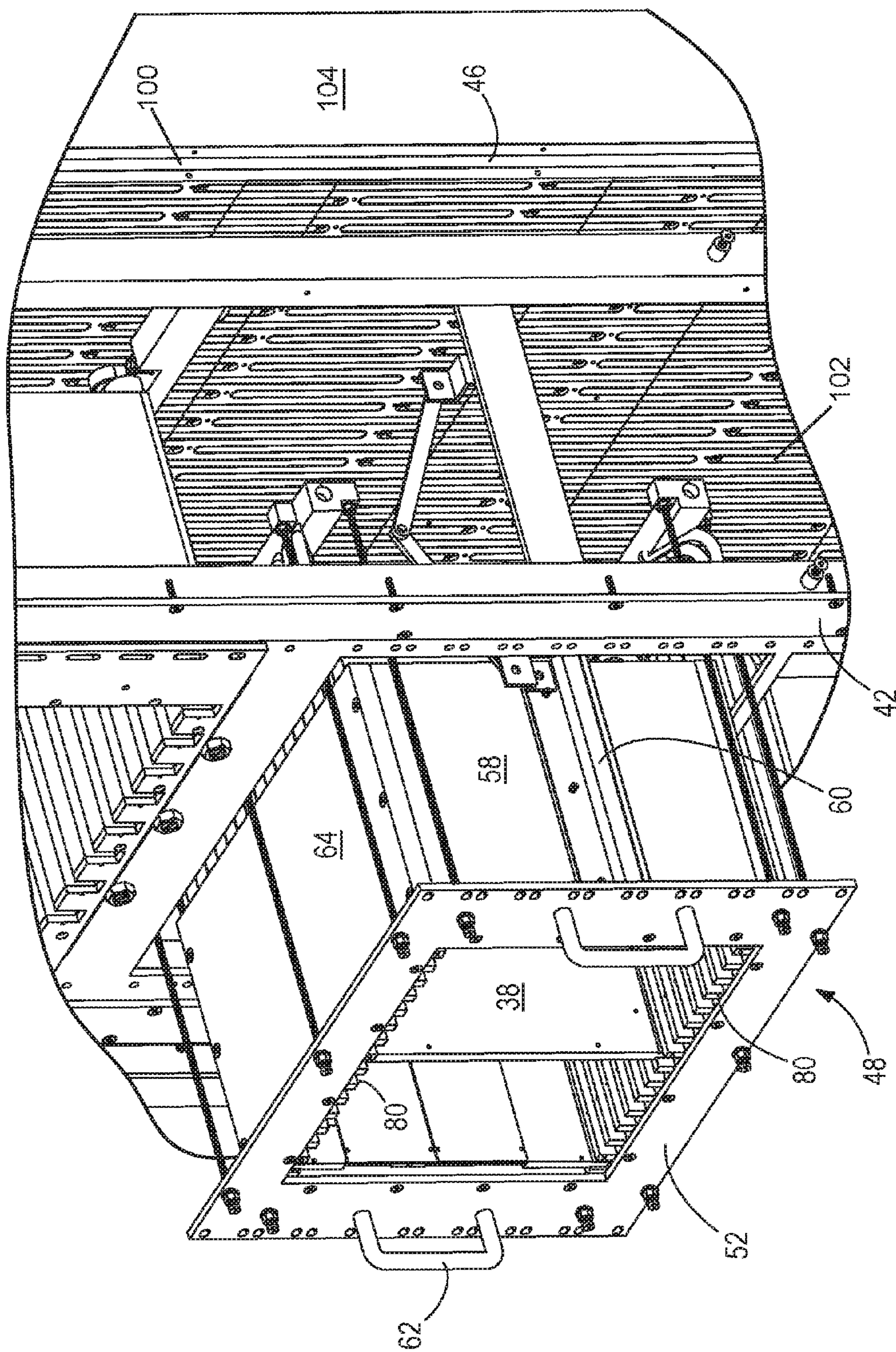


FIG. 3

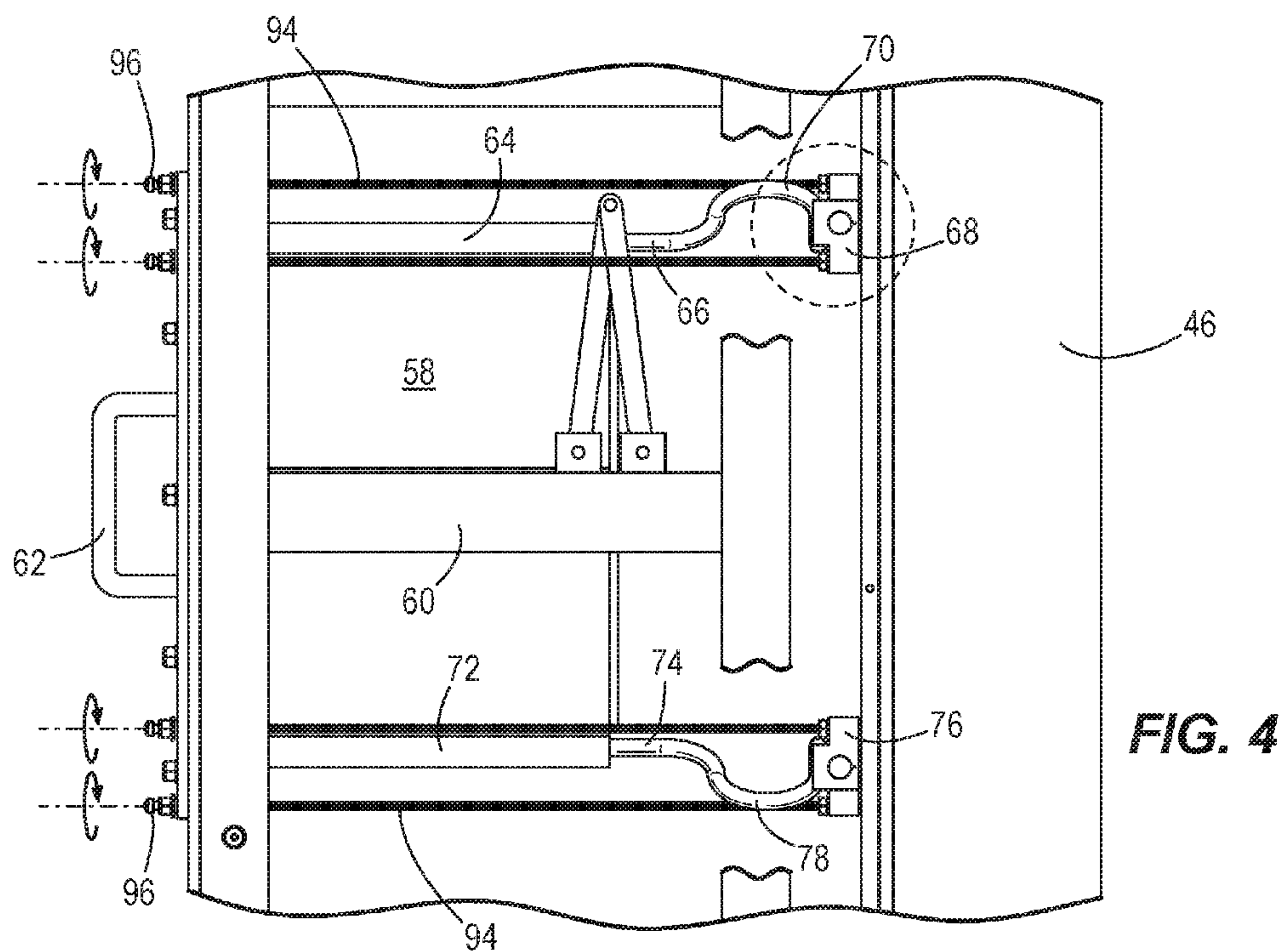


FIG. 4

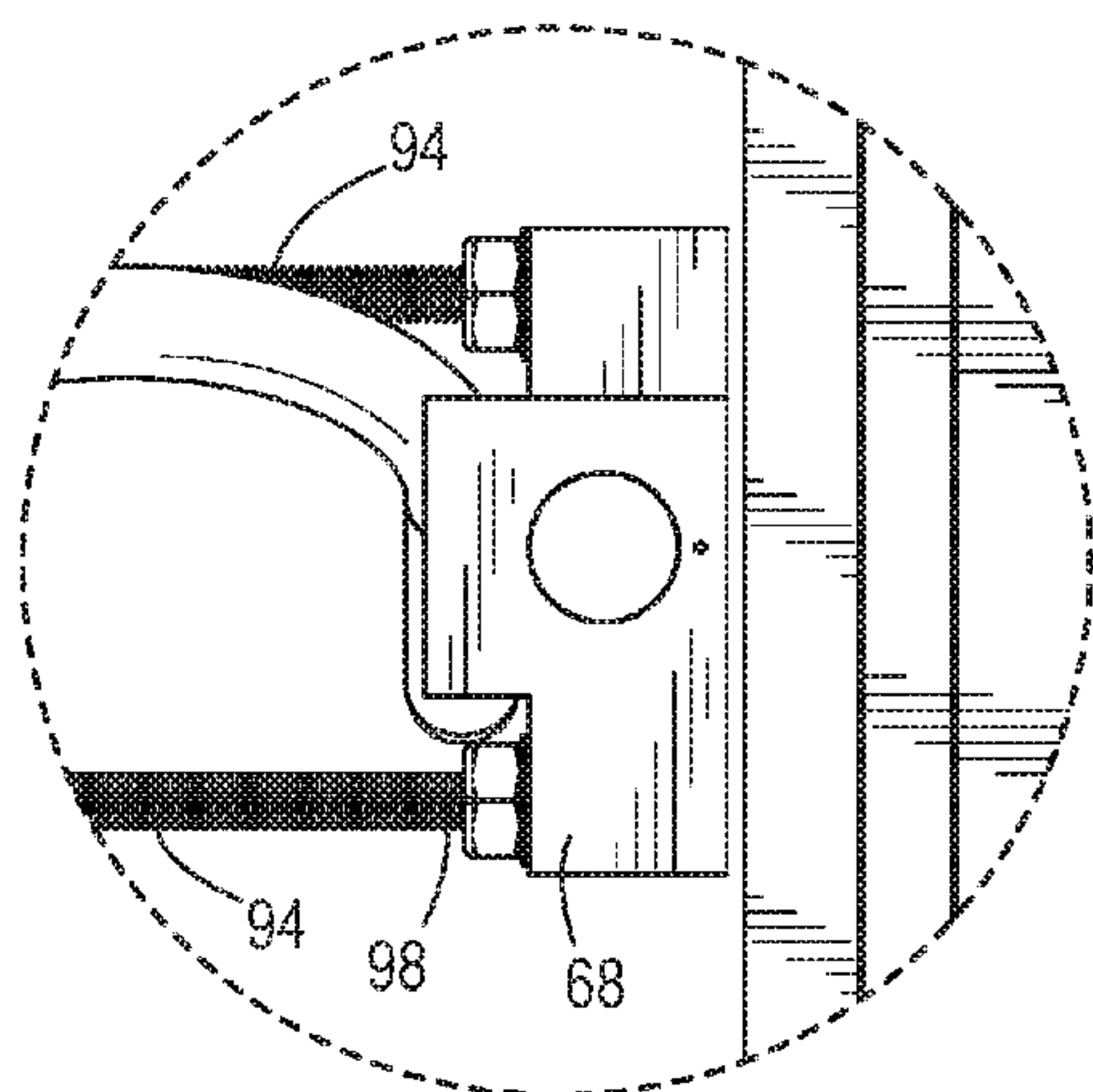


FIG. 5

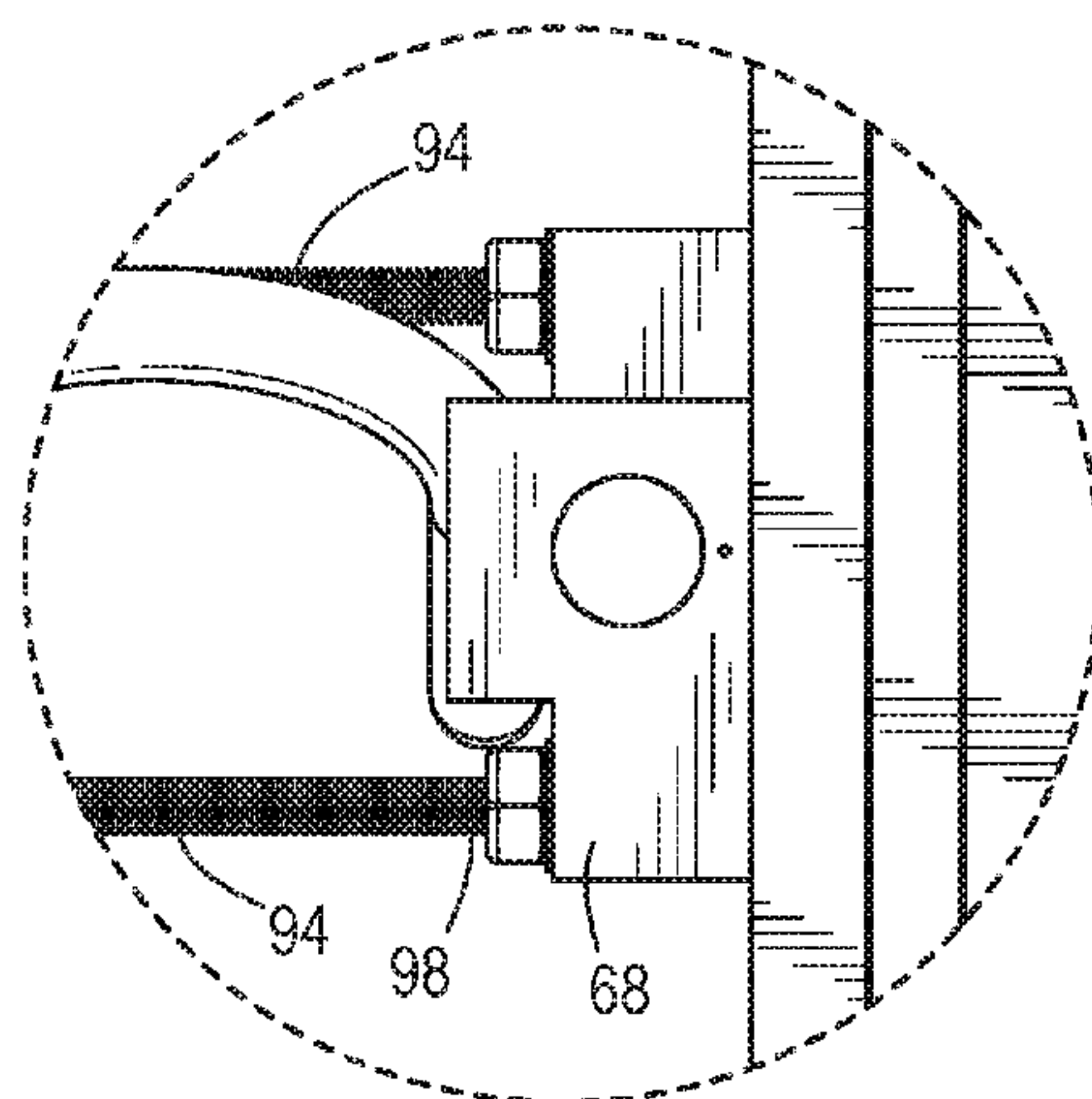


FIG. 6

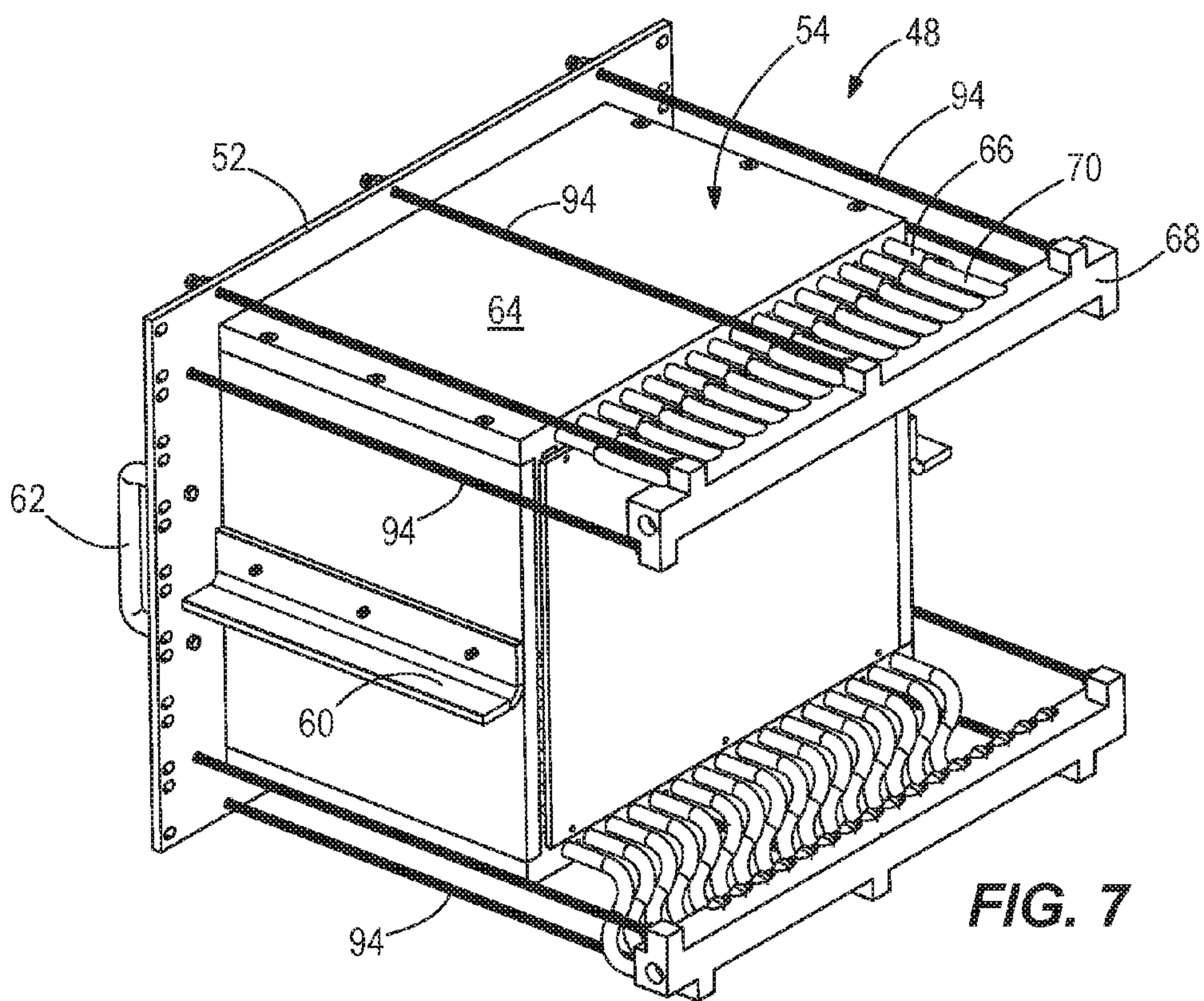


FIG. 7

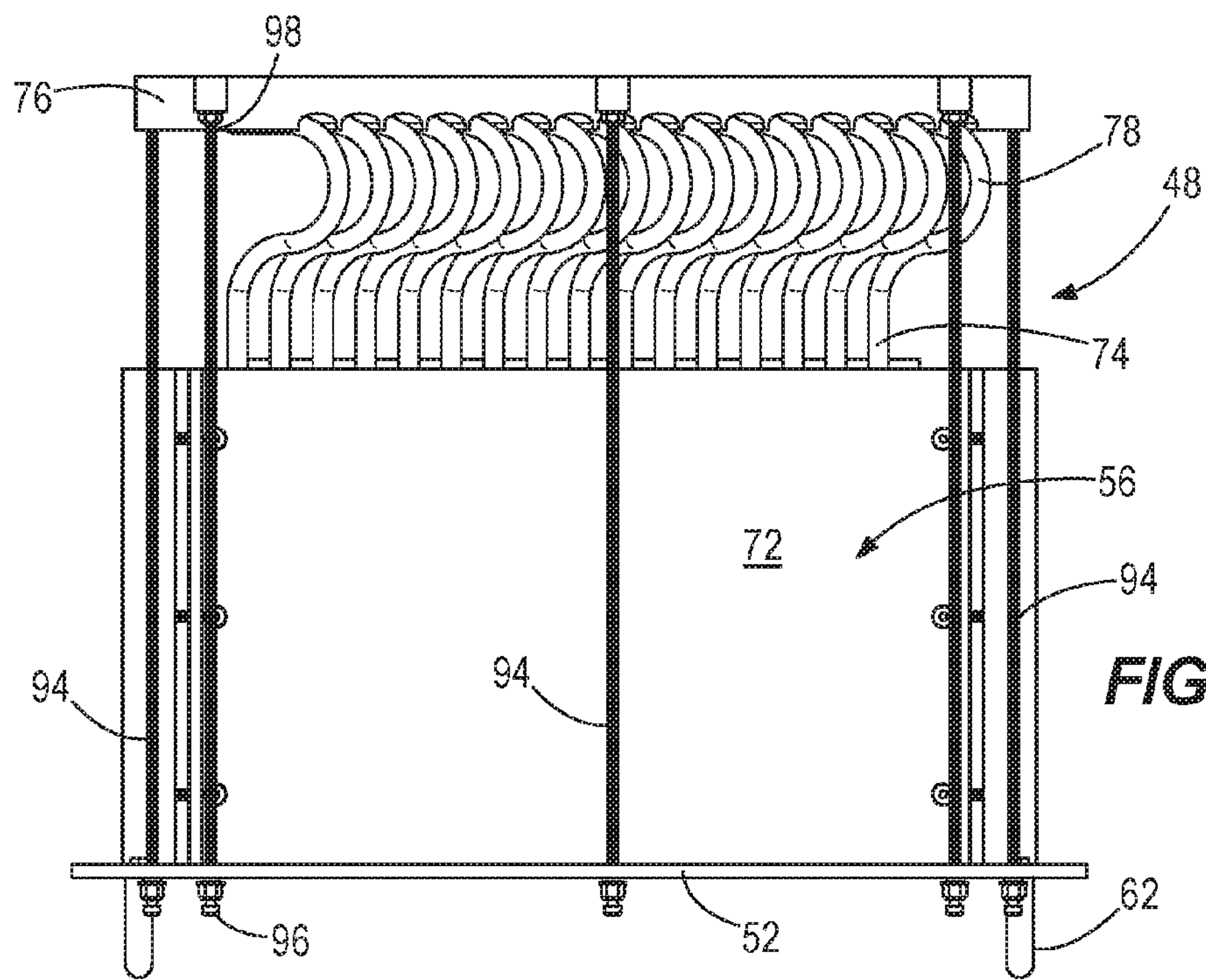


FIG. 8

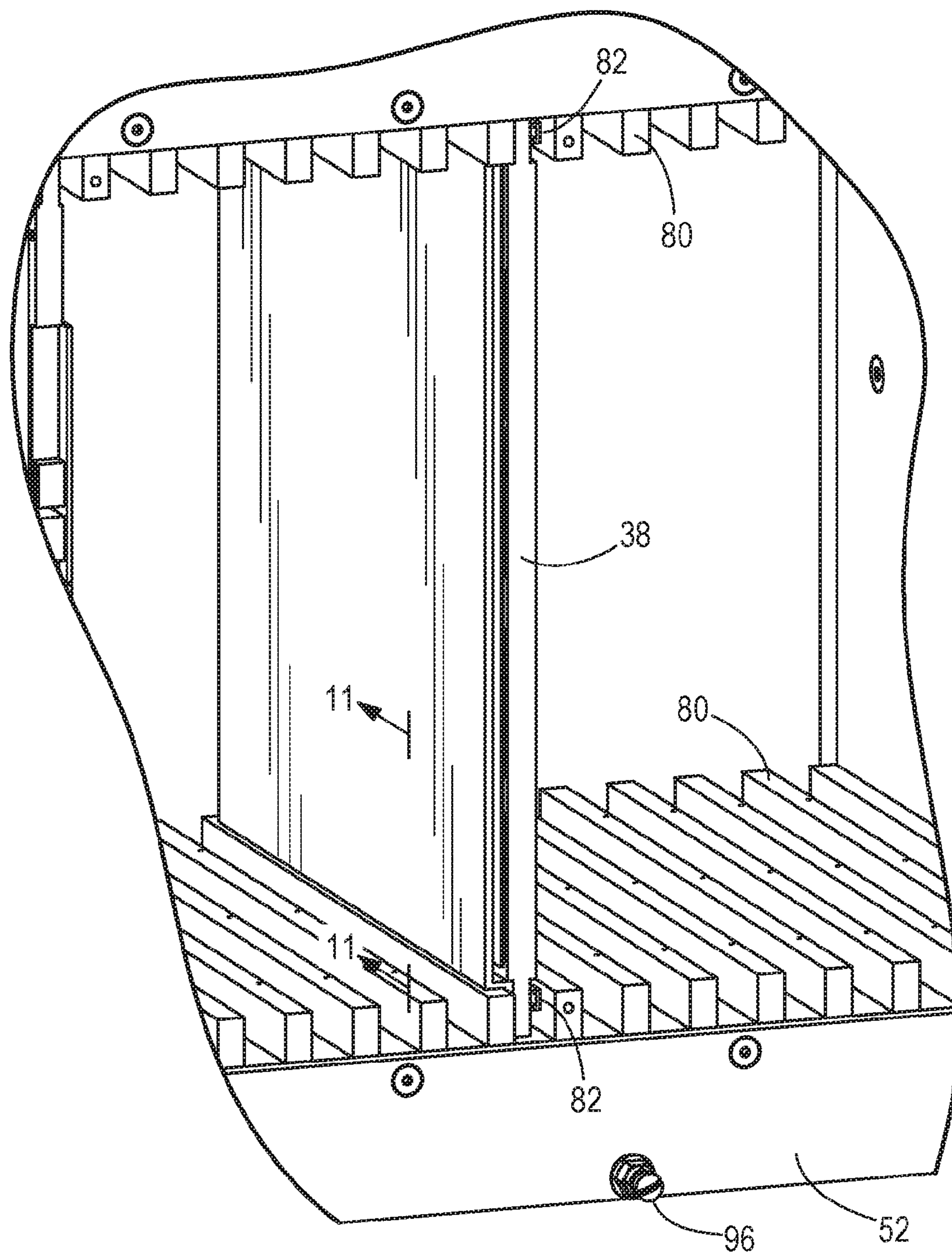


FIG. 9

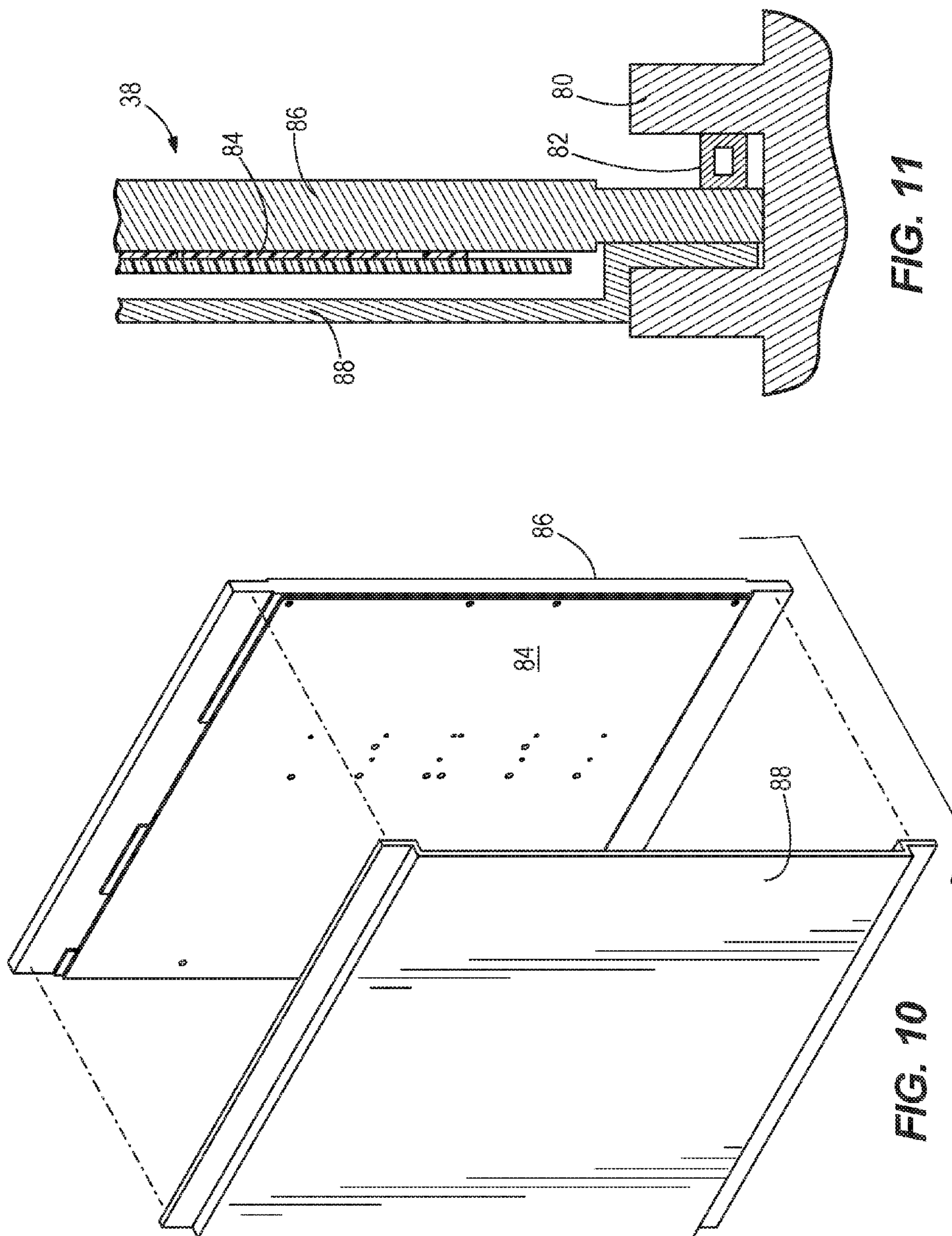


FIG. 11

FIG. 10

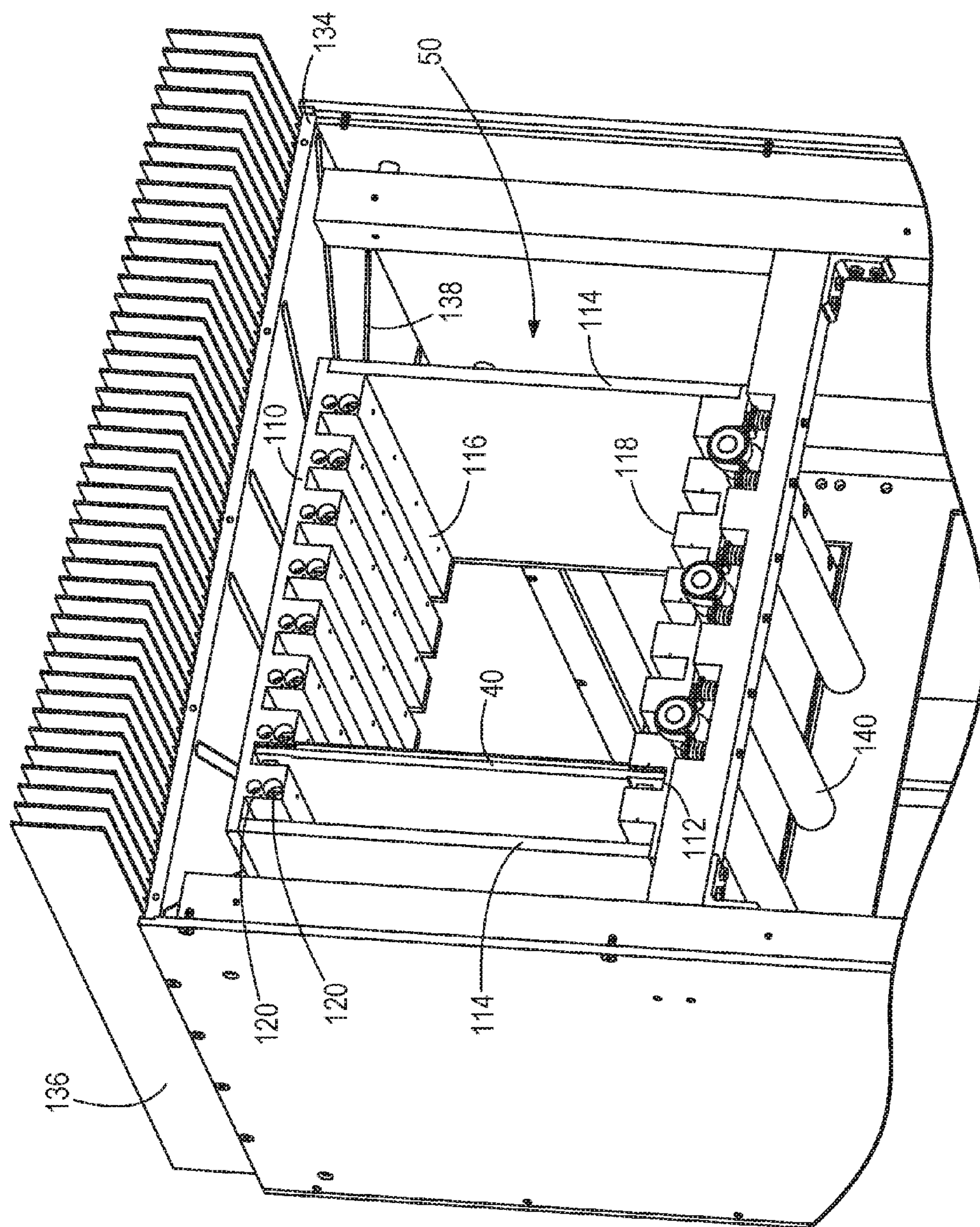


FIG. 12

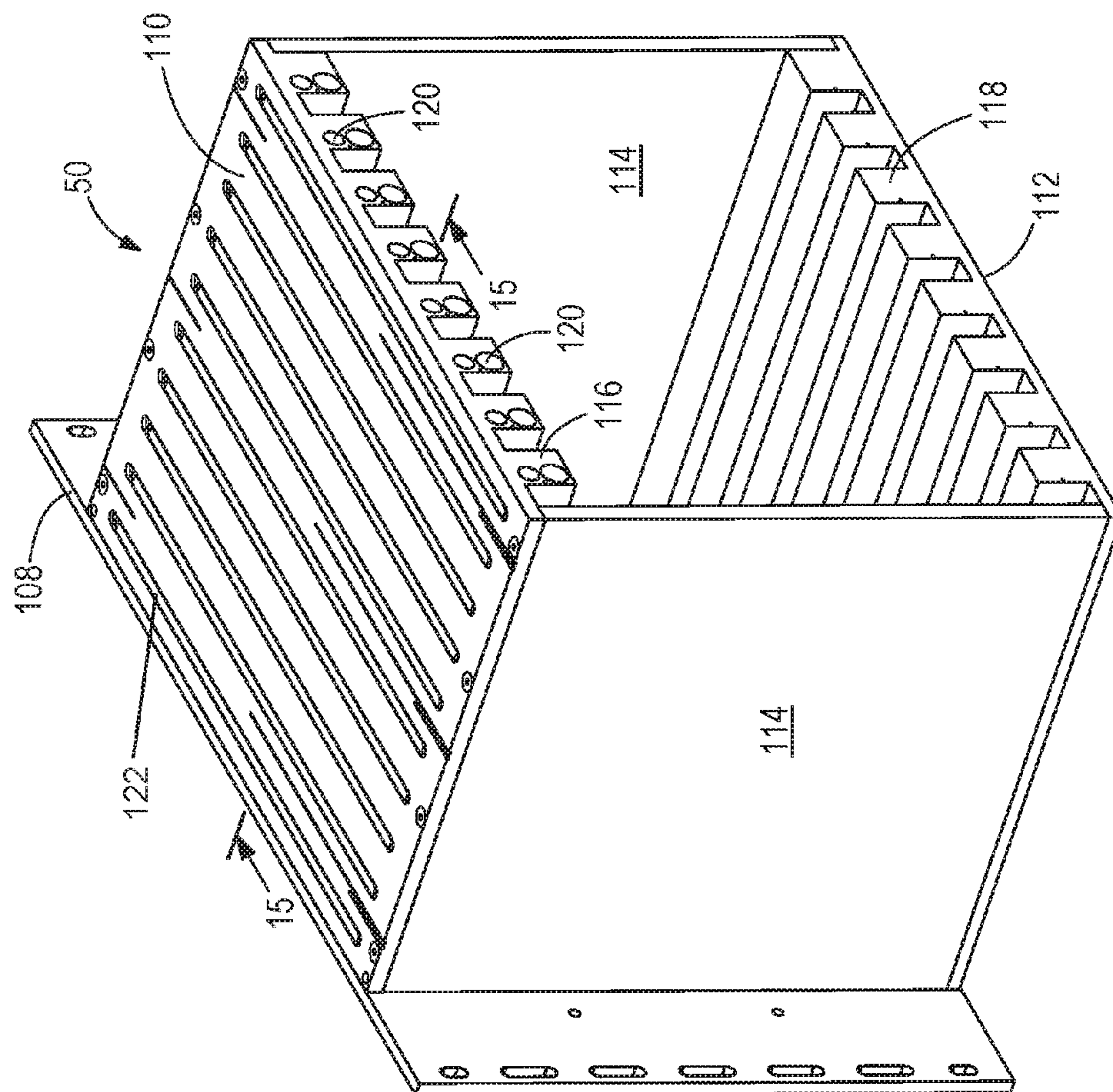


FIG. 14

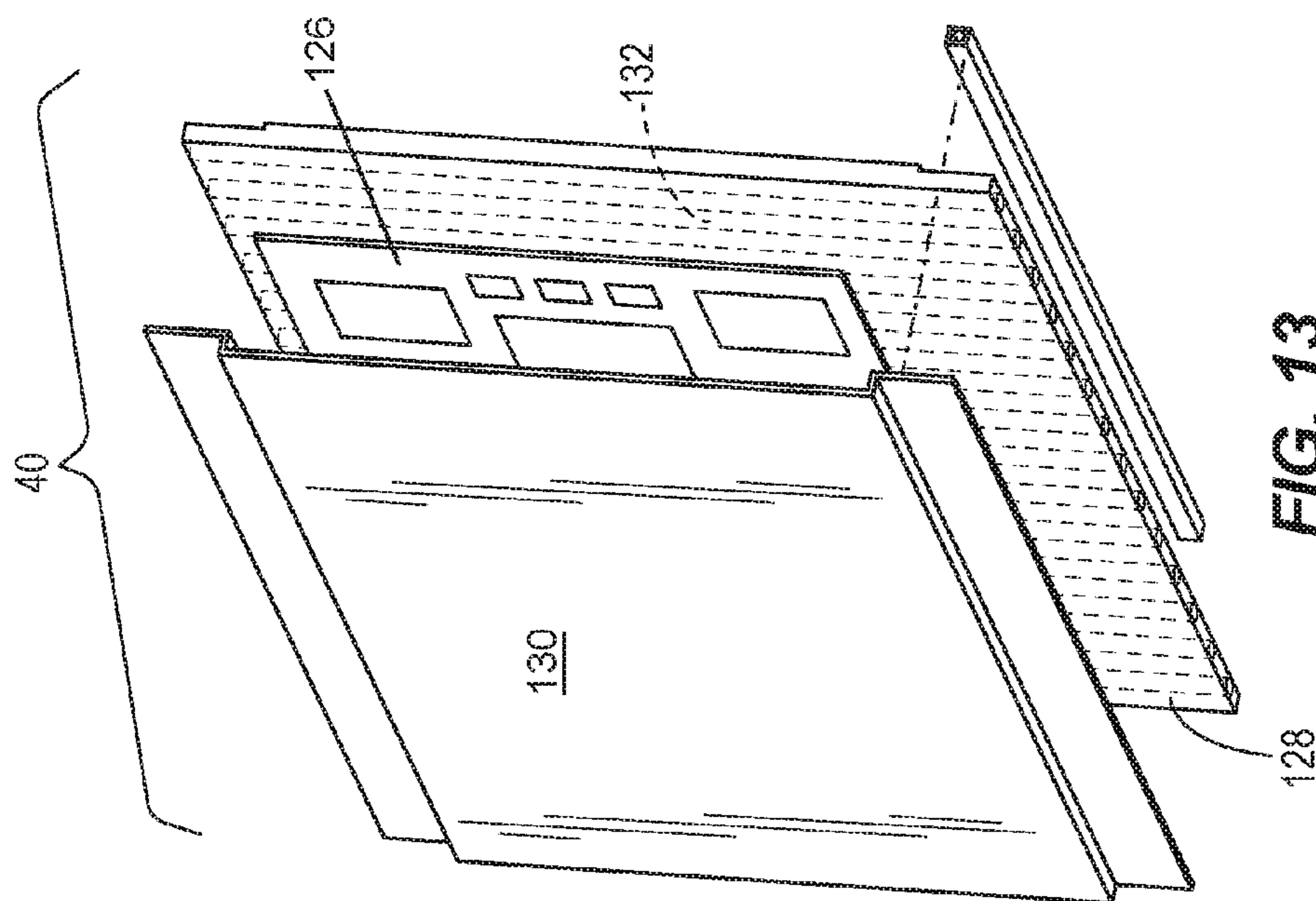


FIG. 13

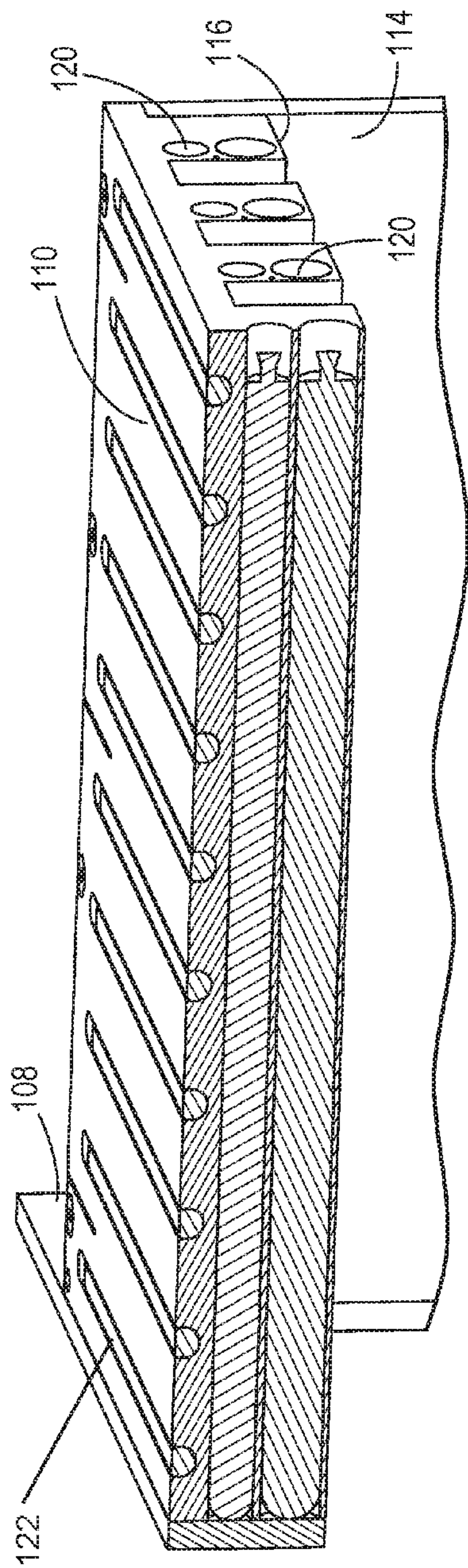


FIG. 15

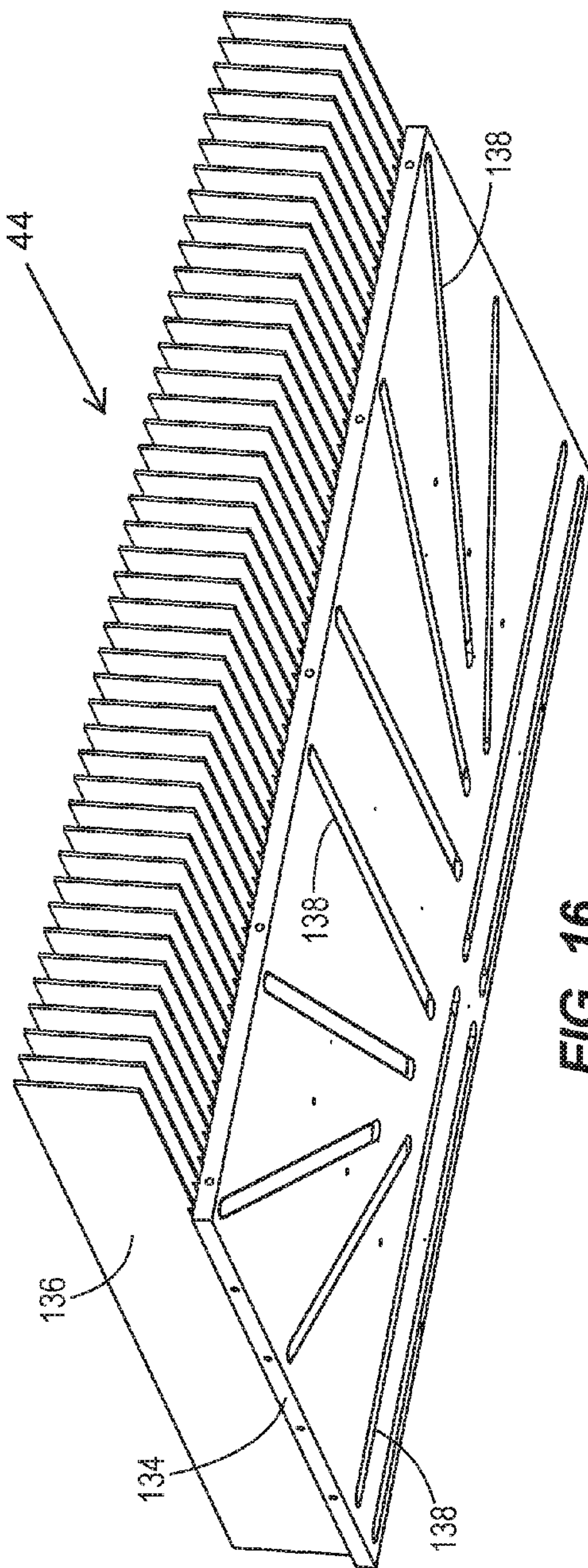


FIG. 16

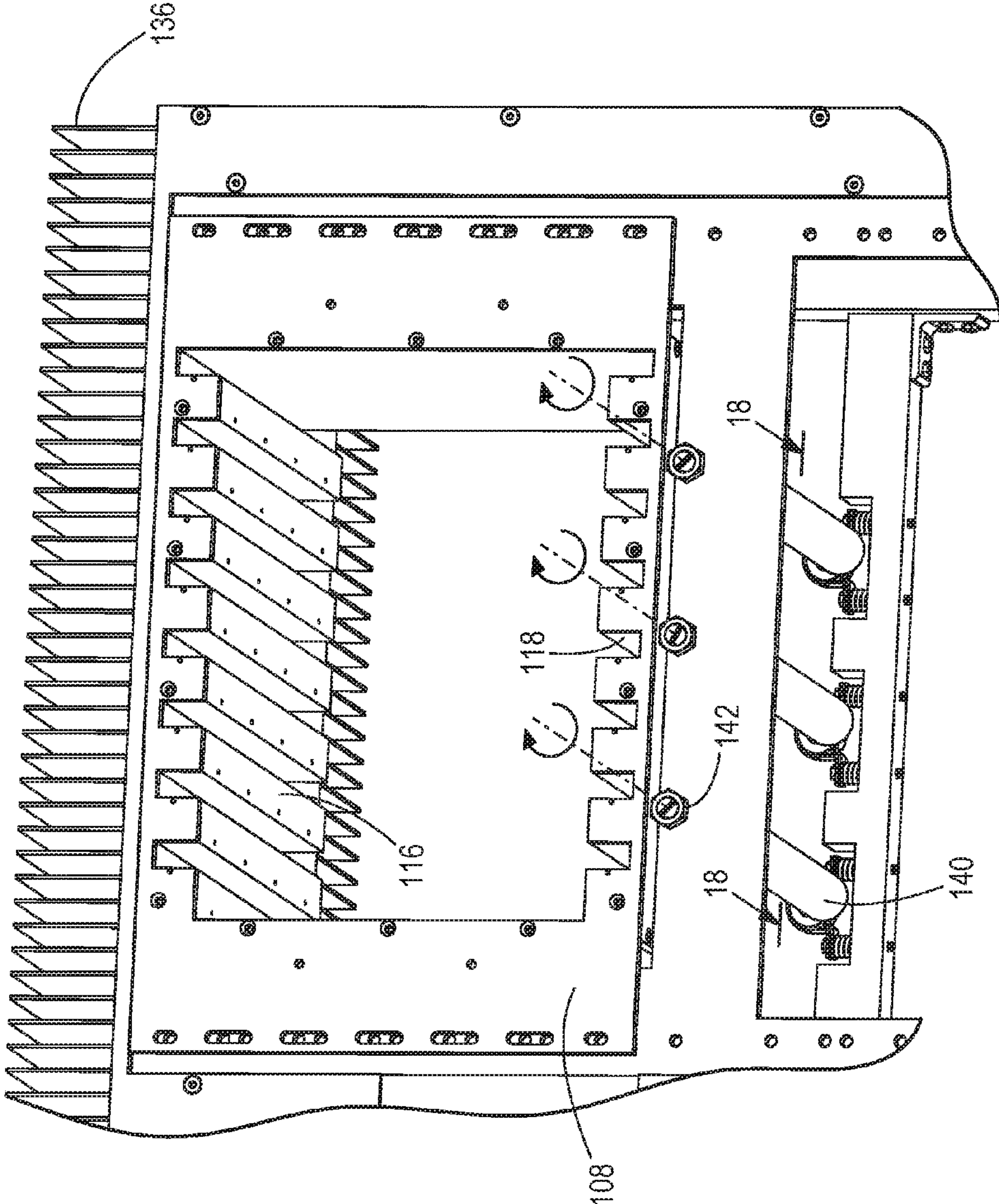


FIG. 17

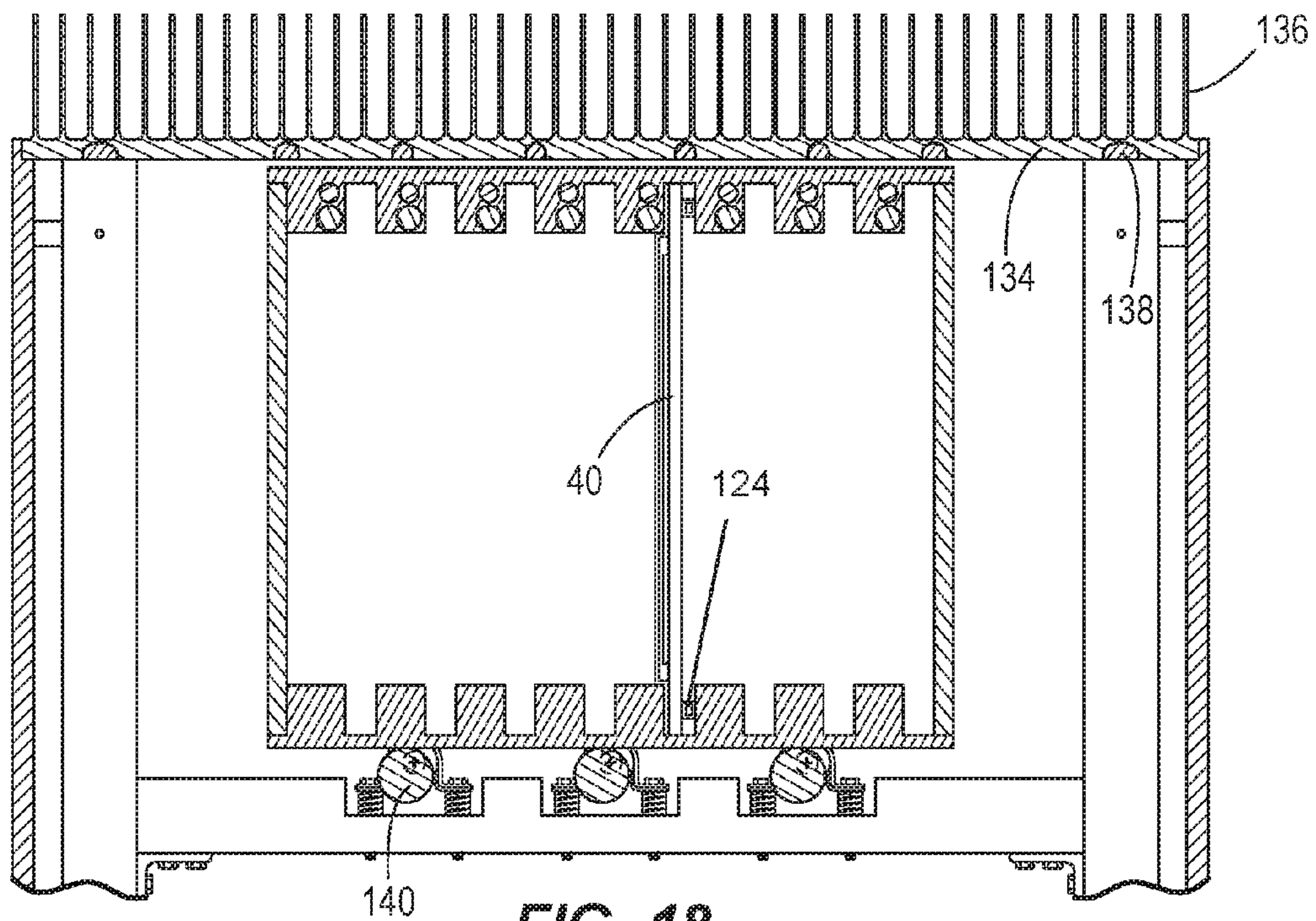


FIG. 18

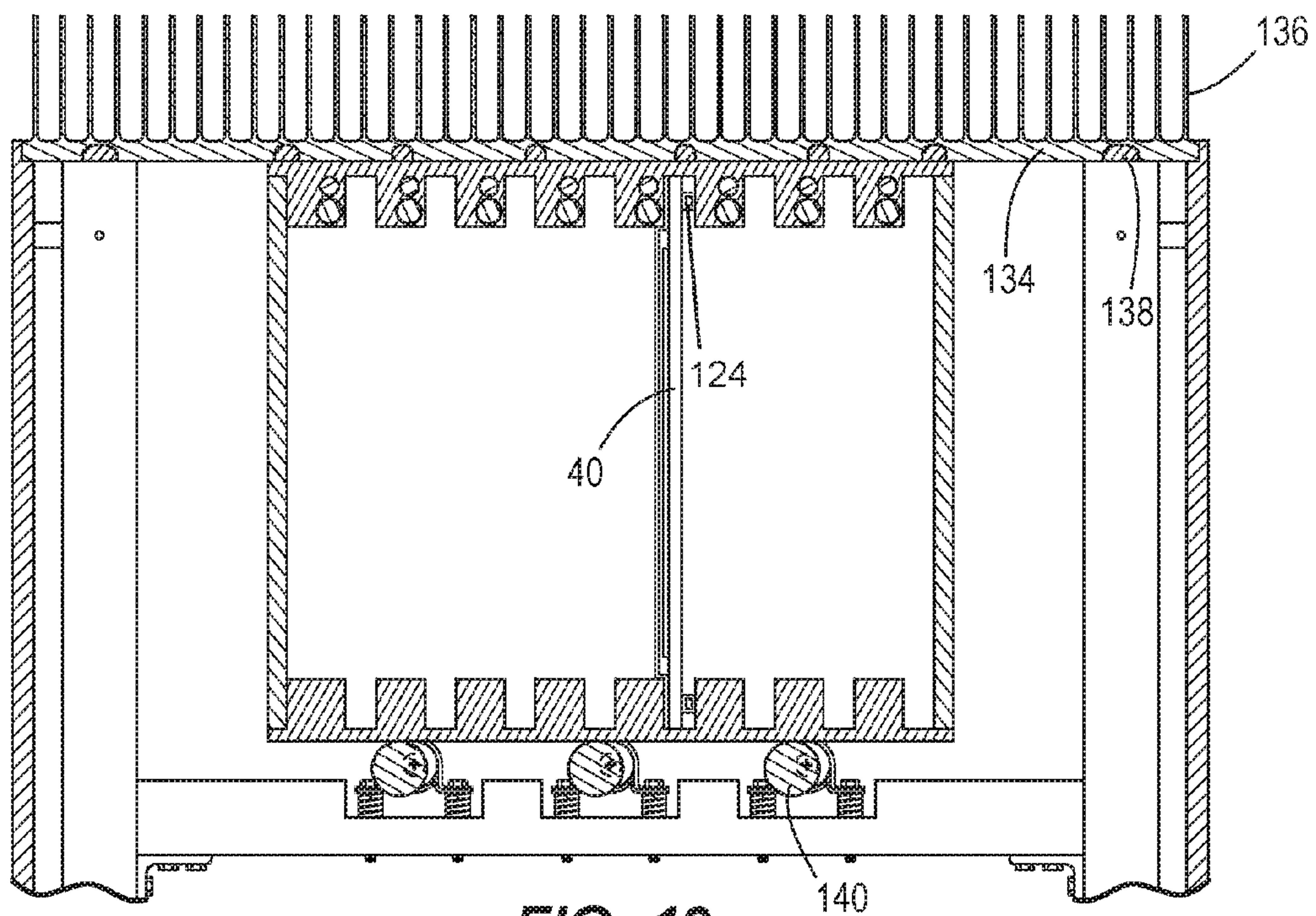


FIG. 19

ELECTRONICS RACK WITH SELECTIVE ENGAGEMENT OF HEAT SINK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority to U.S. patent application No. 62/299,318, filed on Feb. 24, 2016, the entire contents of which are incorporated herein by reference.

FEDERALLY SPONSORED RESEARCH

[0002] This invention was made with government support under purchase order number 7016038 awarded by Bechtel Marine Propulsion Corporation (BMPC)-Knolls Atomic Power Laboratory (KAPL). The government has certain rights in the invention.

BACKGROUND

[0003] In many electronic systems, the efficient cooling of electronic components and other heat sources has become a significant problem. With the advent of large-scale integrated circuit (IC) modules containing many thousands of circuit elements, it has become possible to pack large numbers of electronic components together within a very small volume. These integrated circuit modules generate significant amounts of heat during the course of their normal operation. Since most solid state devices are sensitive to excessive temperatures, a solution to the problem of the generation of heat by large scale IC's in close proximity to one another has become of increasing concern in the industry.

[0004] Current heat transfer systems have proven to be inadequate for removing the high levels of heat generated by heat sources at a low enough thermal resistance and at a sufficiently fast rate. Thus, there has developed a need to more efficiently remove heat from electronics systems.

SUMMARY

[0005] The present invention provides an electronics rack comprising a frame, a heat sink coupled to the frame, and a cage adapted to support an electronic component. The cage is movable between a first position away from the heat sink and a second position toward the heat sink. The rack further includes an eccentric cam operatively positioned between the frame and the cage (e.g., below a portion of the cage) and being rotatable to move the cage between the first and second positions.

[0006] In one embodiment, the cage comprises a cooling brick (e.g., comprising a heat pipe) movable toward and away from the heat sink when the cage moves between the first and second positions. The cooling brick can include a first heat pipe extending generally in a first direction and a second heat pipe extending generally in a second direction transverse (e.g., perpendicular) to the first direction. Preferably, the first and second heat pipes lie in different planes. For example, the cooling brick can comprise a top plate and a top cold rail, wherein the first heat pipe is embedded in the top plate and the second heat pipe is embedded in the top cold rail.

[0007] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a perspective view of an electronics rack embodying the present invention.

[0009] FIG. 2 is an enlarged perspective view of the electronics rack of FIG. 1 showing a lower cage with a portion of the rack removed for clarity.

[0010] FIG. 3 is the view of FIG. 2 with the lower cage slid to an open position.

[0011] FIG. 4 is a partial side view of the electronics rack of FIG. 2.

[0012] FIG. 5 is an enlarged view of the circled portion of FIG. 4 and showing an upper contact bar spaced from a rear heat sink.

[0013] FIG. 6 is the view of FIG. 5 with the upper contact bar moved into contact with the rear heat sink.

[0014] FIG. 7 is a rear perspective view of the lower cage from the electronics rack of FIGS. 1 and 2.

[0015] FIG. 8 is a bottom view of the lower cage of FIG. 7.

[0016] FIG. 9 is an enlarged front view of the cage of FIG. 2 showing a PCB assembly positioned in the cage.

[0017] FIG. 10 is a partially exploded view of the PCB assembly from FIG. 9.

[0018] FIG. 11 is a section view of the assembled PCB assembly taken at line 11-11 in FIG. 9.

[0019] FIG. 12 is an enlarged front perspective view of an upper portion of the electronics rack of FIG. 1 showing an upper cage with portions of the electronics rack removed for clarity.

[0020] FIG. 13 is an exploded perspective view of a power supply assembly.

[0021] FIG. 14 is a perspective view of the upper cage.

[0022] FIG. 15 is a section view of an upper plate from the upper cage taken along line 15-15 in FIG. 14.

[0023] FIG. 16 is a bottom perspective view of an upper heat sink.

[0024] FIG. 17 is a perspective view of a front face of the upper cage and eccentric cams.

[0025] FIG. 18 is a section view of the power supply cage and eccentric cams in a lowered position and taken along line 18-18 in FIG. 17.

[0026] FIG. 19 is the section view of FIG. 18 with the eccentric cams in a raised position.

DETAILED DESCRIPTION

[0027] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the accompanying drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising" or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms "mounted," "connected" and "coupled" are used broadly and encompass both direct and indirect mounting, connecting and coupling. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings, and can include electrical connections or couplings, whether direct or indirect.

[0028] FIG. 1 illustrates an electronics cabinet 30 positioned on a base 32. The cabinet 30 includes a rack 34 and a door 36 hinged to the rack 34. The cabinet 30 is designed to receive multiple printed circuit board (PCB) assemblies 38 and multiple power supply assemblies 40, as described below in more detail.

[0029] The rack 34 includes a frame 42, a substantially horizontally oriented upper heat sink 44 positioned above and supported by the frame 42, a substantially vertically oriented rear heat sink 46 positioned behind the frame 42, and a plurality of lower and upper cages 48,50 slidable into and out of the frame 42. In the illustrated embodiment, there are a total of four cages—three lower cages 48 and one upper cage 50. The three lower cages 48 in FIG. 1 are each adapted to support a plurality of the PCB assemblies 38 (only one PCB assembly is shown in each lower cage in FIG. 1), and the upper cage 50 in FIG. 1 is adapted to support a plurality of power supply assemblies 40, as described below in more detail.

[0030] Referring to FIGS. 2-8, each of the lower cages 48 includes a front face 52, an upper thermal collector 54, a lower thermal collector 56, and left and right side walls 58 to form a generally box-like arrangement. This box-like arrangement is designed to slide into and out of the frame 42 on drawer slides 60 between a closed position (FIG. 2) and an open position (FIG. 3). Handles 62 on the front face 52 facilitate opening the lower cages 48.

[0031] Referring to FIGS. 4-8, the upper thermal collector 54 includes an upper plate 64, upper heat pipes 66 partially embedded in the upper plate 64, and an upper contact bar 68 attached to distal ends of the upper heat pipes 66. As best shown in FIGS. 7-8, each of the upper heat pipes 66 is essentially identical to the others, and each includes a non-linear portion 70 between the upper plate 64 and the upper contact bar 68. In the illustrated embodiment, the non-linear portion 70 is curved to facilitate flexing of the upper heat pipe 66 in order to change the overall length of the upper thermal collector 54.

[0032] Similarly, the lower thermal collector 56 includes a lower plate 72, lower heat pipes 74 partially embedded in the lower plate 72, and a lower contact bar 76 attached to the distal ends of the lower heat pipes 74. As with the upper heat pipes 66, each of the lower heat pipes 74 is essentially identical to each other, and each includes a non-linear portion 78 that is curved to facilitate flexing of the lower heat pipes 74 in order to allow a change in length of the lower thermal collector 56.

[0033] As used herein, a “heat pipe” refers to a closed system of heat transfer in which a small amount of liquid within a sealed and evacuated enclosure is cycled through an evaporation and condensation cycle, as is known in the art. Heat entering the enclosure at one location on the casing or “pipe” evaporates liquid at that location, producing vapor which moves to a cooler location on the casing where it is condensed. The movement of the vapor is motivated by a small vapor pressure differential between the evaporator and the condenser locations. The heat transfer is accomplished when the heat of vaporization, which produces the vapor, is essentially moved with the vapor to the condenser location where it is given up as the heat of condensation. In order for the heat transfer to continue, the condensed liquid must be returned from the condenser to the evaporator where it will again be vaporized. Although this return can be accomplished by something as simple as gravity, capillary wicks

have generally been used to permit heat pipes to be independent of the effects of gravity. Such a wick extends from a location near the condenser, where the liquid originates, to a location at the evaporator where it is needed for evaporation.

[0034] Referring to FIGS. 9-11, a series of cold rails 80 is positioned on a lower surface of the upper plate 64 and on an upper surface of the lower plate 72 to thereby define a series of elongated slots adapted to receive the plurality of PCB assemblies 38. A resilient wedge lock 82 (FIG. 11) is positioned in each slot to secure each of the PCB assemblies 38 in the corresponding slots, as described below in more detail.

[0035] Each of the PCB assemblies 38 includes a printed circuit board 84, a primary cold plate 86 and a secondary cold plate 88. As shown in FIGS. 9-11, the primary and secondary cold plates 86,88 sandwich the printed circuit board 84 to facilitate heat transfer from the printed circuit board 84 to the cold plates 86,88. Preferably, the cold plates 86,88 are made from aluminum to enhance the rate of heat transfer. As shown in FIG. 11, each of the PCB assemblies 38 is inserted into a corresponding slot in a lower cage 48 and is held in place by being sandwiched between the corresponding wedge lock 82 and the corresponding cold rail 80.

[0036] Each of the lower cages further includes an upper adjuster and a lower adjuster adapted to adjust the length of the upper and lower thermal collectors 54,56, respectively. Referring to FIGS. 7-8, each of the upper and lower adjusters includes five threaded rods 94 connected between the front face 52 and the corresponding contact bar 68,76. The proximate end 96 of each of the threaded rods 94 is keyed for rotation relative to the front face 52. In addition, each proximate end 96 extends slightly from the front face 52 and includes means to facilitate rotation of the threaded rod 94, as shown in FIG. 4. In the illustrated embodiment, the proximate end 96 of each threaded rod 94 is slotted to facilitate insertion of a flathead screwdriver and rotation of the threaded rod 94. The distal end 98 of each of the threaded rods 94 is threaded into a corresponding threaded hole in the corresponding contact bar 68,76. By rotating the threaded rods 94, the position of the corresponding contact bar 68,76 relative to the rear heat sink 46 (and relative to the front face 52) will be adjusted. In the illustrated embodiment, this adjustment can be up to five millimeters of displacement.

[0037] Referring to FIGS. 1-3, the rear heat sink 46 includes a rear plate 100 positioned at a rear of the rack 34 in a position where it can be contacted by the contact bars 68,76 upon closing of the lower cages 48 (with appropriate adjustment of the upper and lower adjusters 90,92). The rear heat sink 46 further includes rear heat pipes 102 embedded in the rear plate 100 in order to distribute heat received from the contact bars 68,76 throughout a greater volume of the rear plate 100. The rear heat sink 46 further includes rear fins 104 extending from a rear surface of the rear plate 100 to facilitate passive dissipation of heat to the surrounding air.

[0038] In operation, each of the lower cages 48 can be slid out of the rack 34 to facilitate insertion and removal of PCB assemblies 38. After all of the PCB assemblies 38 are properly installed in the corresponding slots, the lower cage 48 can be slid back into the rack 34. However, because of the variability and tolerances of the cabinet 30, it is possible that the upper and lower contact bars 68,76 do not properly engage the rear heat sink 46. Without solid engagement

between the contact bars **68,76** and the rear heat sink **46**, heat dissipation from the thermal collectors **54,56** to the rear heat sink **46** is substantially compromised. In order to facilitate solid contact between the contact bars **68, 76** and the rear heat sink **46**, the threaded rods **94** can be rotated to move the contact bars **68,76** from a spaced position (FIG. **5**) to a contacting position (FIG. **6**) relative to the rear heat sink **46**.

[0039] Referring to FIG. **12**, the upper cage **50** is designed to receive a plurality of power supply assemblies **40** (only one power supply assembly is shown in FIG. **12**). The construction and arrangement of the upper cage **50** is slightly different from the lower cages **48** in that the upper cage **50** promotes heat transfer upward, while the lower cages **48** promote heat transfer rearward. The illustrated upper cage **50** includes a front face **108**, a top plate **110**, a bottom plate **112**, and left and right side walls **114** connecting the top and bottom plates **110,112** to form a generally box-like arrangement. As with the lower cages **48**, the upper cage **50** includes a series of top and bottom cold rails **116,118** (secured to the top and bottom plates **110,112**, respectively) that define slots for receiving the power supply assemblies **40**. However, in this arrangement, the top cold rails **116** are different from the bottom cold rails **118**. Specifically, as shown in FIGS. **12, 14, and 15**, the top cold rails **116** each include two embedded heat pipes **120** for distributing heat in each of the top cold rails **116**. In addition, the top plate **110** is different from the bottom plate **112** in that the top plate **110** includes a plurality of embedded heat pipes **122** positioned transverse to the orientation of the top cold rails **116** (see FIGS. **14-15**). These transverse heat pipes **122** transfer and distribute heat throughout the top plate **110**. For convenience, the combined assembly of the top plate **110** and the top cold rails **116** is referred to as a “cooling brick,” it being understood that a cooling brick would not necessarily need to have those components.

[0040] As with the lower cages **48**, the upper cage **50** includes wedge locks **124** (FIGS. **18-19**) positioned in the slots to facilitate securing the power supply assemblies **40** in the slots.

[0041] Similar to the PCB assemblies **38**, the power supply assemblies **40** include a power supply board **126**, a primary cold plate **128**, and a secondary cold plate **130** (see FIG. **13**). The power supply board **126** is sandwiched between the primary and secondary cold plates **128,130** to facilitate the transfer of heat from the power supply board **126**. Each power supply assembly **40** is designed to be inserted into a pair of opposed top and bottom slots (formed by the top and bottom cold rails **116,118**, respectively) and held in place by being sandwiched between the wedge locks **124** and the corresponding top and bottom cold rails **116, 118**, as shown in FIGS. **18-19**.

[0042] Referring to FIG. **13**, each of the cold plates **86,88,128,130** can further include heat pipes **132** embedded in the cold plate. In the illustrated embodiment, these heat pipes **132** are only illustrated in connection with the primary cold plate **128** of the power supply assembly. These heat pipes **132** (shown in phantom in FIG. **13**) can be positioned to promote the transfer of heat in the desired direction. For example, when used in the PCB assemblies **38** for the lower cages **48**, the heat pipes **132** can be arranged to promote heat transfer upward and downward to the upper and lower thermal collectors **54,56**, respectively. When used in connection with the power supply assembly **40**, the heat pipes

132 can be embedded and positioned to promote transfer of heat upward to the top plate **110** and eventually to the upper heat sink **44**.

[0043] Referring to FIG. **16**, the upper heat sink **44** includes a distribution plate **134** and a series of upper fins **136** extending upward from the distribution plate **134**. The distribution plate **134** is positioned directly above the top plate **110** of the upper cage **50** and includes a series of heat pipes **138** that distribute heat in the distribution plate **134**. The illustrated heat pipes **138** are in multiple orientations, such as parallel to the front face **108**, perpendicular to the front face **108**, and oblique to the front face **108**. The illustrated upper fins **136** are arranged parallel to each other and perpendicular to the front face **108**.

[0044] The upper cage **50** is designed to have a certain amount of vertical play relative to the frame **42** and relative to the upper heat sink **44**. For example, in the illustrated embodiment, the upper cage **50** can be moved vertically about five millimeters relative to the frame **42**. This vertical play allows the upper cage **50** to be moved vertically until the top plate **110** of the upper cage **50** contacts the distribution plate **134** of the upper heat sink **44**. Referring to FIG. **17**, this vertical movement can be accomplished using a series of eccentric cams **140** mounted to the frame **42** and positioned under and in contact with the upper cage **50**. As best shown in FIGS. **18-19**, rotation of the eccentric cams **140** will cause the upper cage **50** to move upwardly from a lowered position (FIG. **18**) to a raised position (FIG. **19**) to thereby facilitate the creation of contact between the top plate **110** and the distribution plate **134** of the upper heat sink **44**. Each of the eccentric cams **140** includes a cam actuator **142** that extends from a front surface of the frame **42** to facilitate rotation of the eccentric cams **140**. In the illustrated embodiment, the cam actuators **142** comprise hex heads that facilitate rotation of the eccentric cams **140** using a standard wrench.

[0045] Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the invention as described.

1. An electronics rack comprising:
 - a frame;
 - a heat sink coupled to the frame;
 - a cage adapted to support an electronic component, the cage being movable between a first position away from the heat sink and a second position toward the heat sink; and
 - an eccentric cam operatively positioned between the frame and the cage, the eccentric cam being rotatable to move the cage between the first and second positions.
2. The electronics rack of claim 1, wherein the heat sink is positioned above the cage.
3. The electronics rack of claim 1, wherein the cage comprises a cooling brick movable toward and away from the heat sink when the cage moves between the first and second positions.
4. The electronics rack of claim 3, wherein the cooling brick comprises a heat pipe.
5. The electronics rack of claim 3, wherein the cooling brick comprises:
 - a first heat pipe extending generally in a first direction; and
 - a second heat pipe extending generally in a second direction transverse to the first direction.

6. The electronics rack of claim 5, wherein the first and second heat pipes lie in different planes.

7. The electronics rack of claim 5, wherein the cooling brick comprises a top plate and a top cold rail, wherein the first heat pipe is embedded in the top plate and the second heat pipe is embedded in the top cold rail.

8. The electronics rack of claim 1, wherein the eccentric cam is positioned below a portion of the cage.

9. The electronics rack of claim 8, wherein the eccentric cam comprises a plurality of eccentric cams that are each rotatable to move the cage between the first and second positions.

10. The electronics rack of claim 1, wherein the cage defines a plurality of slots adapted to support a plurality of electronics modules.

11. An electronics rack comprising:

a frame;

a heat sink coupled to the frame;

a cage adapted to support an electronic component, the cage being movable between a first open position away from the heat sink and a second position toward the heat sink;

a cooling brick supported by and movable with the cage, wherein the cooling brick is in thermal communication with the heat sink when the cage is in the second position.

12. The electronics rack of claim 11, wherein the heat sink is positioned above the cage.

13. The electronics rack of claim 12, wherein the second position is above the first position.

14. The electronics rack of claim 11, wherein the cooling brick comprises a heat pipe.

15. The electronics rack of claim 11, wherein the cooling brick comprises:

a first heat pipe extending generally in a first direction;

and

a second heat pipe extending generally in a second direction transverse to the first direction.

16. The electronics rack of claim 15, wherein the first and second heat pipes lie in different planes.

17. The electronics rack of claim 11, wherein the cage defines a plurality of slots adapted to support a plurality of electronics modules.

* * * * *